

The 1997 Eastern Bering Sea Shelf-Wide Coccolithophorid Bloom: Ecosystem Observations and Hypotheses



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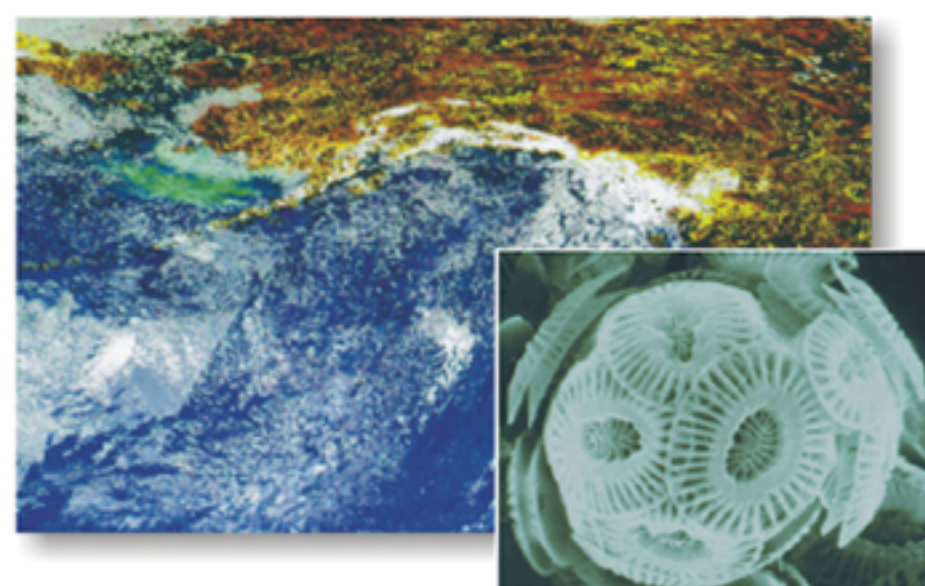


FIGURE 1: SeaWiFS True Color Image of the Southeastern Bering Sea Coccolithophore Bloom, 18 - 25 September 1997. The bloom was first observed in July. The area affected by the bloom (turquoise patch) is approximately 300 x 700 km. Insert-Scanning Electronic Micrograph of the bloom organism, *Emiliana huxleyi*. This small phytoplankton (approx. 6 μm diameter) covers itself with calcium carbonate plates or coccoliths.



FIGURE 2: Station Map for Southeast Bering Sea Carrying Capacity (SEBSCC) Monitoring Stations. The stations were occupied February, April, May, July, and September of 1997. Data used in this poster were collected at Mooring 2 (Middle Shelf Domain) and along four transects extending from the Pribilof Islands (Lines A - D). Two other projects also made observations on the bloom, the NSF-sponsored Inner Fronts Study and NOAA's National Marine Mammal Laboratory.

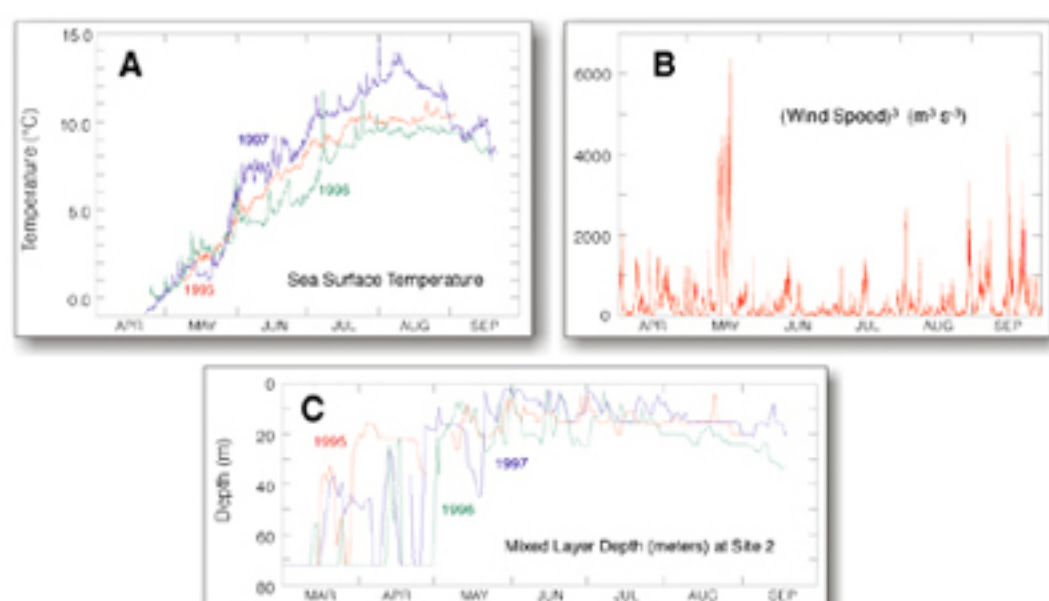


FIGURE 3: Time Series of Sea Surface Temperature, Wind and Mixed Layer Depth at Mooring 2. In 1997 summer sea surface temperature was approx. 2 - 4°C warmer than usual (A). Wind speed cubed, a proxy for wind mixing, shows uncharacteristically low values during spring except for one storm in May (B). The mixed layer depth (MLD) shoaling occurred later in 1997 than 1995 and the shallow 1997 MLD (10 - 15 m) was attributed to a weak thermocline formed from solar radiation retained during anomalously long periods of cloudless skies and low wind velocity.

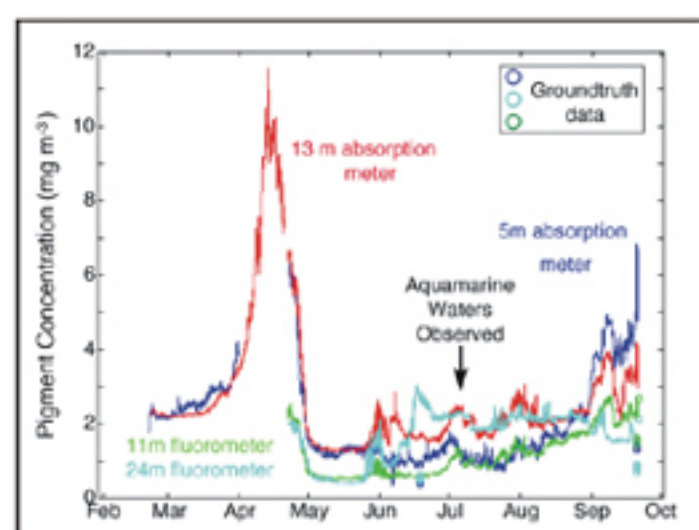


FIGURE 4: Chlorophyll Estimates At Mooring 2 From Absorbance and Fluorescence Measurements (Davis et al., 1997). The chlorophyll time series shows a large spring bloom, 5-10 day variability during the summer, and several fall blooms. There were no dramatic changes defining the coccolithophore bloom, but visible coccolithophore blooms can occur without large changes in chlorophyll (5000 cells $\text{ml}^{-1} \approx 1 \text{ mg Chl m}^{-3}$).

FIGURE 5: Nitrate and Silicate at Mooring 2, February, April, and July, 1997. Vertical profiles of nitrate and silicate show a normal progression from high surface values in February to low values in April after the peak of the spring phytoplankton bloom. What was different about the 1997 nutrient profiles was the depleted concentrations found below the pycnocline in July. Normally a much larger nutrient pool (8 - 10 μM nitrate and 20 - 30 μM silicate) remains below the pycnocline for the duration of the summer.

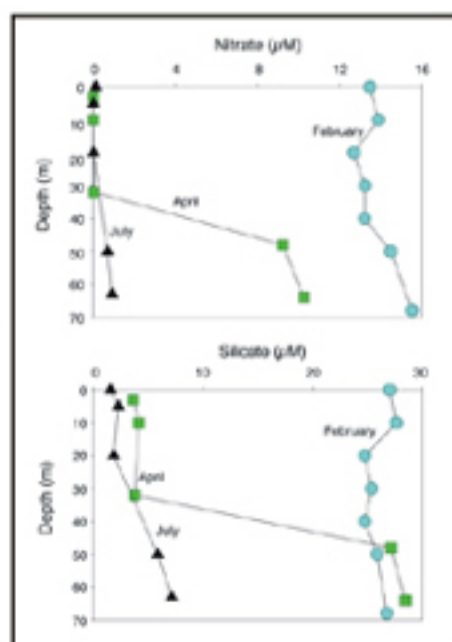


FIGURE 6: September Vertical Distribution of Coccolithophorids and Coccoliths at the Pribilof Islands (Line B). Note that the number of detached coccoliths was approx. 100 times greater than the number of intact cells. If there were no other autotrophic or heterotrophic nano- and microplankton, then the organic carbon available to mesozooplankton particle grazers would be only 30 - 45 $\mu\text{g l}^{-1}$ in the upper 10 - 15 m. Estimates of particulate organic carbon from chlorophyll (carbon:chlorophyll = 50) are approx. 75 - 150 $\mu\text{g l}^{-1}$ for the same time period. Therefore coccolithophores were not the only taxon in the nano- and microplankton.

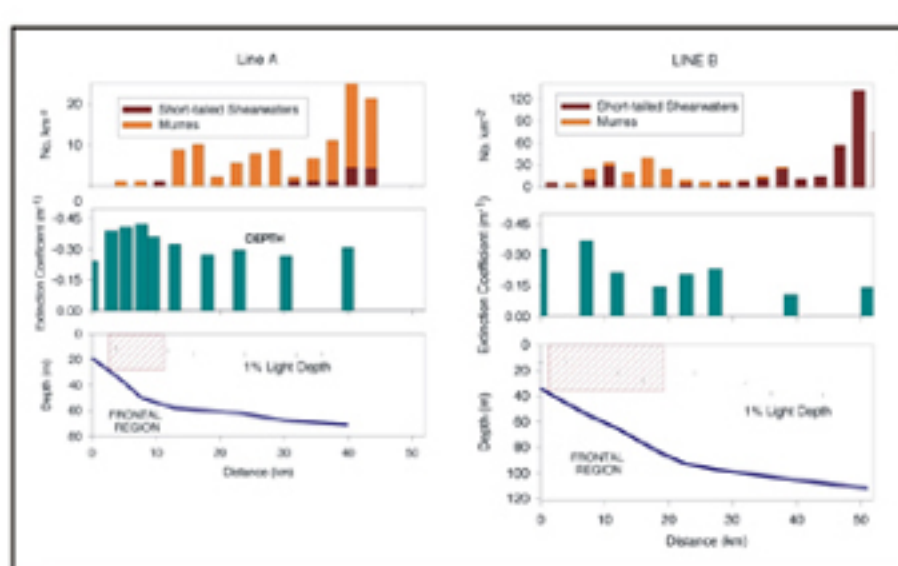
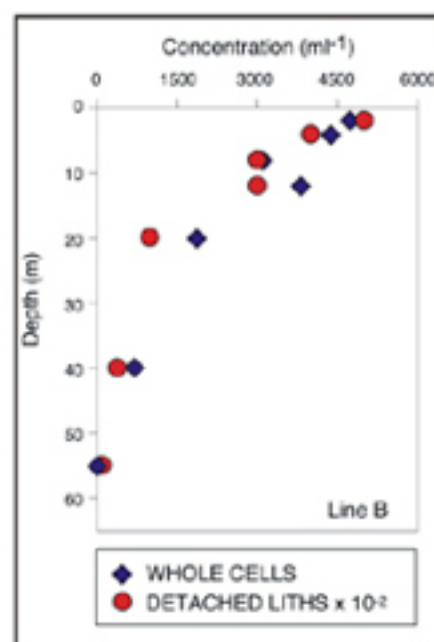


FIGURE 8: Depth of the Bloom in September as Determined by ROV Video Observations on Lines A - D. Light scattering by the coccoliths may have dramatically reduced the light available for visual predators (e.g. juvenile pollock, diving seabirds, and marine mammals). There was general agreement between extinction coefficients determined from the PAR sensor (Fig. 7) and the maximum depth as observed by the ROV ($r = 0.77$, $P < 0.005$, $N = 12$).

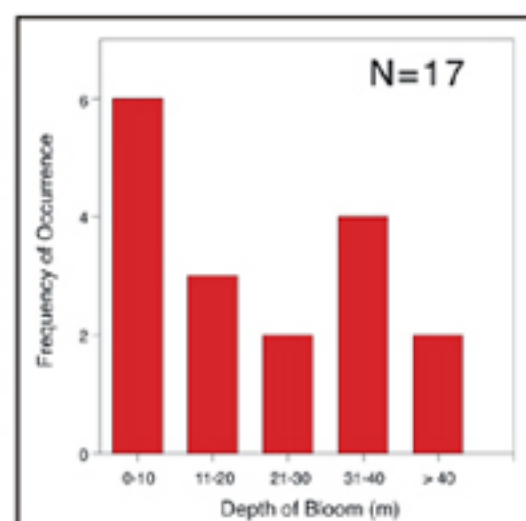


FIGURE 7: September Light Extinction Coefficients, 1% Incident Light Depth and Diving Seabird Density in Waters Surrounding the Pribilof Islands. Water without particles would have an extinction coefficient of -0.04 m^{-1} . Note that the highest extinction coefficients were sometimes associated with the frontal region between well-mixed and stratified waters. Short-tailed shearwaters were less abundant in 1997 than during previous years (1994 - 1996). The increase in murre concentration on Line A occurs seaward of the highest light extinction coefficients. The same is true on Line B. High concentrations of shearwaters were at the end of the transects where the lowest extinction coefficients were found. Distributions of prey for the seabirds (murres - juvenile pollock; shearwaters - euphausiids) is ongoing.

REFERENCES

Davis, R.R., C.C. Moore, J.R.V. Zaneveld, and J.M. Napp. 1997. Reducing the effects of fouling on chlorophyll estimates derived from long-term deployments of optical instruments. *J. Geophys. Res.* 102(C3):5851-5856.

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CONCLUSIONS

- An ecosystem-wide perturbation occurred in the Bering Sea this past year. A large, persistent bloom of coccolithophorids covered the shelf from the Alaska Peninsula north to beyond St. Lawrence Island.
- Nutrients for phytoplankton growth were stripped from both the upper and lower portions of the water column. Normally nutrient concentrations in the lower portion of the water column remain relatively high throughout the summer. Mixing by storms, new production within and below the pycnocline, or reduced advection of nutrients from the slope are hypothesized to be responsible for this anomalous situation.
- Weak water column stratification, dominated by thermal rather than salt gradients probably had a significant role in the pulses of summer production observed at Mooring 2.
- The coccolithophore bloom occurred concurrently with anomalously high surface water temperatures, low silicate concentrations, and a shallow mixed layer caused by long periods of clear, sunny weather and low wind mixing.
- Light scattering by the coccoliths had a significant impact on the submarine light available for visual observations and presumably affected visual predators as well (juvenile pollock, seabirds, and marine mammals).
- These physical and biological anomalies in the Bering Sea ecosystem may have been responsible for the high mortality of short-tailed shearwaters observed around the Inner Front/Coastal Waters and the catastrophically low return of sockeye salmon to Bristol Bay, Alaska.